Lessons Learned from Event Relocation Validation Testing

Xiaoping Yang, István Bondár, Keith McLaughlin
SAIC

Jackson Hole, Wyoming, 3 October 2001

Outline

- **Validation testing and SSSC test results**
- **Lessons on data**
  - ***Coverage, GT accuracy, outliers/misassociations***
- **Lessons on mixing calibrated and uncalibrated phases in location**
  - ***Pg and Lg SSSCs, teleseismic SSSCs***
- **Lessons on model and model error**
  - ***CUB model, SAIC-HRV model***
- **Lessons on evaluation/assessment**
- **Lessons on depth**
- **Conclusions**
- **Lessons learned and future work**

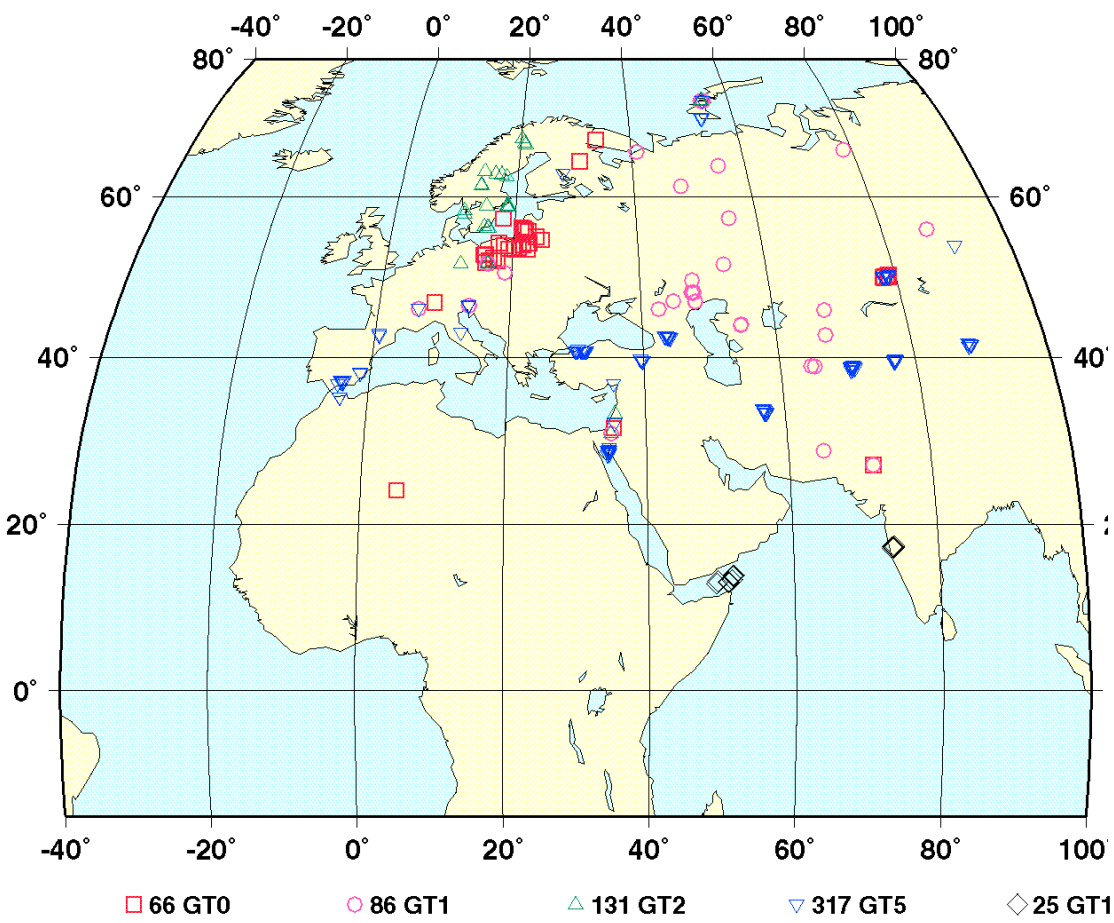
Validation testing

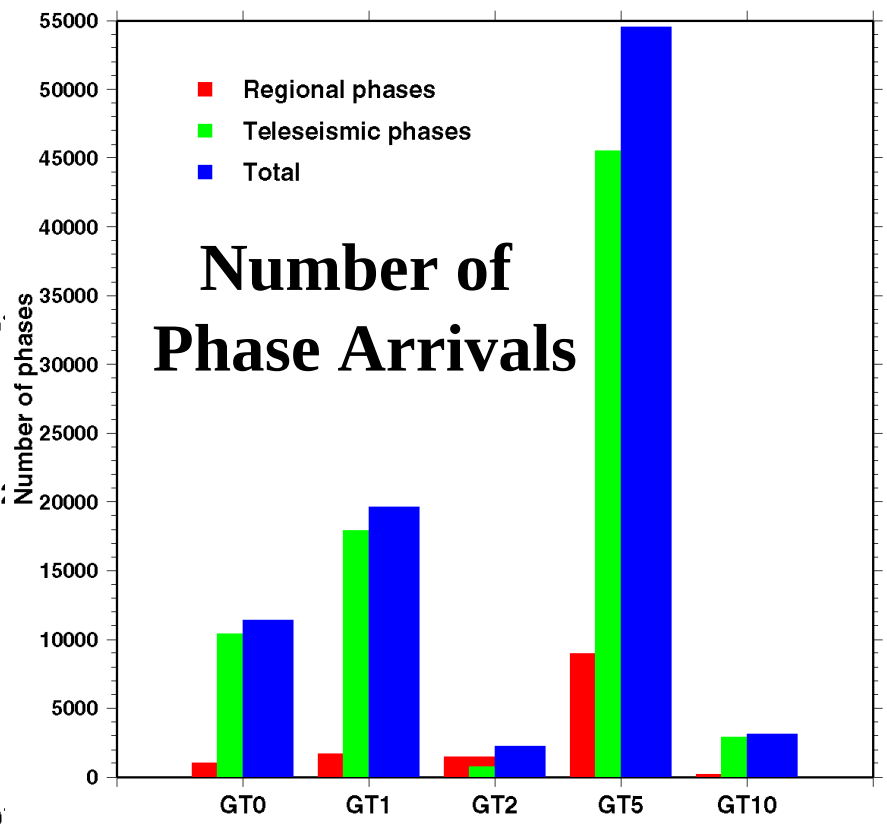
- **Two models: CUB; SAIC-HRV**
- **Offline testing:**
  - **Four test data sets**
  - **Model validation (SSSCs for all stations) and IMS location improvement (SSSCs for IMS/surrogates)**
  - **Effect of mixing calibrated and uncalibrated regional and teleseismic data**
  - **Major evaluation metrics: mislocation, error ellipse area, 90% coverage, oigin time and error, and misfit.**
- **Online (both GA and ARS) testing: IMS SSSCs**

SSSC test results

- **Benchmark using GT events in Fennoscandia: new 3D CUB SSSCs and old 1D SSSCs perform similarly.**
- **Group-2 GT0-GT10 events: CUB SSSCs and model errors perform well w.r.t. IASPEI.**
- **MORT GT10 events: marginal improvement in locations and low 90% coverage using CUB SSSCs**
- **Candidate GT5 EHB events (poor resolution power): CUB SSSCs "do no harm" to locations. The model underpredicts 90% error but correctly predicts 50%.**
- **SAIC-HRV model does not perform well compared to the CUB model.**
- **Online testing of the CUB model shows no significant operational impact on the system.**

GT0-10 events
used in relocation testing





~ 600 GT0-GT10 events (>3 Pn, Sn phases)

~ 10,000 Pn and Sn paths

~ 1,500 stations with Pn and Sn SSSCs

Lesson 1 – (a) data coverage

- **Despite the effort in collecting GT5 or better events throughout the study region, currently the event geographic distribution is still limited.**

➢ **As a result, some areas are better validated than others, and some areas are yet to be validated (e.g. North Africa).**

➢ **More data need to be collected for better coverage in Phase 2. Compared to Phase 1, it is expected that the work will be harder and slower, and the goal may be lower than GT5.**

Lesson 1 – (b) GT accuracy

- **At present the data quality in our collections is inhomogeneous, even within the same GT category.**
- **For instance, within a cluster the original reference events may be better located than the derived events. Relocation results show better improvement for the original reference cluster events using SSSCs.**
- **The current GT estimates may change as further data development is carried out.**
- **Since the improvement in event location is less than 10 km using SSSCs, it is important to assess the reference events as accurately as possible.**

Lesson 1-
(c) outliers and misassociations

- **Locations are sensitive to outliers and misassociation when the azimuthal distribution of network is poor.**
- **At this time it is hard to separate the effect between data and models when analyzing location results.**

Lesson 2- mixing calibrated with uncalibrated phases in location

- **Mixing calibrated and uncalibrated data in event location dilutes/degrades the benefits of calibration.**

➢**Developing Pg and Lg SSSCs should have a high priority in Phase 2.**

➢**Teleseismic phase calibrations may also be explored since teleseismic phases play a dominant role in IMS event location.**

➢**Regardless of whether we reduce model error in Phase 2, teleseismic calibration will be required to get the next significant improvements.**

Lesson 3- model and model error

- **Compared to the CUB model, the Pn and Sn corrections from the SAIC-HRV model are somewhat fast. The model should be examined for bias and possibly improved in Phase 2.**
- **1D modeling errors were assumed in both the CUB and SAIC-HRV model relocation tests.**
  - **At 90% confidence the errors are about right.**
  - **At 50% (median) the errors are too large.**
  - **At high confidence (>95%) the errors are too small.**

Lesson 4- evaluation

- All events were included in validation testing and evaluation for objectiveness.
- The standard evaluation metrics and reference event relocation have limited power in assessing performance improvement.
- Evaluation metrics/statistics should be improved in Phase 2.

Lesson 5- depth

- **In Phase 1 the SSSCs are generated for the source depth of 10 km.**
- **Current reference events do not have depth resolution.**
- **In Phase 2 the SSSCs will take into account of source depths. Relocation validation testing will be challenging.**

Conclusions

- **CUB model Pn and Sn SSSCs are successfully tested online and offline.**
  - **To be recommended to the CCB for operational use at the PIDC/IDC.**
- **The SAIC-HRV model performed poorly in relocation tests.**
  - **Investigation required to improve the model and error.**

Lessons learned and future work

- **Effort required for Phase 2:**
  - **Pg and Lg SSSCs necessary for regional calibrations**
  - **Teleseismic SSSCs needed for the next level of significant improvement**
  - **GT data to be improved for better geographic coverage and better assessment of GT accuracy, misassociations, and outliers**
  - **Investigation/improvement of the SAIC-HRV model needed**
- **Effort useful for Phase 2:**
  - **More realistic modeling errors may improve performance**
  - **Further development of evaluation metrics/statistics useful**
  - **Depth SSSCs to be developed will face challenges in validation testing**